
पथांतर कार्यों की डिज़ाइन के लिए मापदंड

भाग 2 बाँध के ढाँचे में पथांतर चैनल और
खुला कटाव अथवा नलिका
(पहला पुनरीक्षण)

Design of Diversion Works — Criteria

Part 2 Diversion Channel and Open Cut or
Conduit in the Body of Dam

(*First Revision*)

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भारतीय मानक ब्यूरो

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FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Flood Management, Erosion Management and Diversion Works Sectional Committee had been approved by the Water Resources Division Council.

Before the actual construction is taken up in the river bed, the water of the river channel must be temporally diverted so as to permit the works to be done in dry or semi-dry areas. Diversion works provide working area free from water and river flow for constructing hydraulic structures. These works, as far as possible, are so designed that when the diversion needs are over, these may be utilized partially or fully in the main projects as spillways, bottom outlets, irrigation outlets, head race or tail race tunnels and also for flushing of deposited sediments upstream. The method and magnitude of diversion works will depend primarily upon the cross-section of the valley, the type of dam, diversion discharge and the bed material in the river. However, in some specific cases, the choice of a dam may depend on diversion arrangement, for example an earth dam is not feasible where diversion works cannot prevent overtopping of the dam.

This standard was first published in 1994; however, the Committee responsible for the formulation of this standard decided to revise it based on the experience gained since then as well as considering technological development in the field. In this revision, the important modifications are made in Fig. 3, Fig. 4, Clause 4.1.2.2, Clause 4.2 (b) and Clause 5.2 (b).

This standard is published in two parts. Part 1 of this standard covers the criteria for design of coffer dams of different types, namely masonry, concrete, colloidal concrete, earthen, rockfill, steel and timber coffer dams. The passage for diversion of water can be broadly classified into three categories, namely open channel, open cut or conduit in the permanent works which are covered in this Part.

Indian Standard

DESIGN OF DIVERSION WORKS — CRITERIA

PART 2 DIVERSION CHANNEL AND OPEN CUT OR CONDUIT IN THE BODY OF DAM

(*First Revision*)

1 SCOPE

This standard covers the criteria for design of open channel and open cut or conduit in the body of the dam as diversion works.

2 REFERENCES

The following standards listed below contain provisions which, through reference in this text constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below.

<i>IS No.</i>	<i>Title</i>
4410 (Part 12) : 1993	Glossary of terms relating to river valley projects : Part 12 Diversion works (<i>first revision</i>)
12966 (Part 2) : 1990	Code of practice for galleries and other openings in dams: Part 2 Structural design
13912 : 1993	Closure of diversion channel and open cut or conduit in the body of the dam — Code of practice
14815 : 2000	Design flood for river diversion works — Guidelines

3 TERMINOLOGY

For the purpose of this standard, the definitions given in IS 4410 (Part 12) shall apply.

4 OPEN CHANNEL

4.1 At sites where diversion of flow through tunnels or close conduits is not possible (due to topographical and geological considerations) or proves to be uneconomical, diversion through excavated channels called diversion channels is effected. Diversion channels are often classified according to the type of diversion, namely single stage or multiple stage diversion scheme. In the former which is more suitable for narrow valleys, the same set of diversion channel and coffer dams is utilized throughout the period of construction. In the latter, which is generally suitable for wide valleys, the channels and coffer dams are shifted from place to place in accordance with phasing of the work. A more useful classification, however, is

based on the type of the dam to be constructed, namely diversion channel for masonry or concrete dams and that for the earth or rockfill dams. The following guidelines are followed for their design.

4.1.1 *Diversion Channels for Masonry/Concrete Dams*

Concrete or masonry dams could be allowed to get overtopped during floods when construction activity is not in progress. The resulting damage is either negligible or could be tolerated without much concern. Therefore, it is customary to adopt diversion flood which is just adequate to be handled during non-monsoon season, when construction activity of the dam is continued. Generally the largest observed non-monsoon flood or 25 years return period flow, calculated on the basis of non-monsoon yearly peaks is adopted as a diversion flood. This is generally a small fraction of the design flood of the spillway and, therefore, diversion channel required to handle this flood is obviously small. Advantage is also taken of passing the floods over partly completed dam or spillway blocks, thereby keeping the diversion channel of relatively smaller size. In such a case a small excavated channel either in the available width of the river or one of the banks of the river proves to be adequate. Construction sluices are located in such excavated channels which allow passage of non-monsoon flows without hindrance to the construction activity. Such sluices are subsequently plugged when the dam has been raised to adequate height. If the pondage is not allowed even when the dam has been raised to sufficient height, the river outlets are often provided in the body of the non-overflow or overflow dam to pass the non-monsoon flows which later on are kept for permanent use after completion of construction. If the diversion channel is excavated on one of the river banks, it is possible to use the same for locating an irrigation outlet, a power house or a spillway depending upon the magnitude and purpose of the project. Fig. 1 and Fig. 2 show typical layouts of diversion channel for masonry/concrete dams in wide and narrow rivers respectively.

4.1.2 *Diversion Channel for Earth/Rockfill Dams*

4.1.2.1 Earth or rockfill dams should not be allowed to be overtopped by floods during construction. Therefore, it is imperative to ensure that the highest

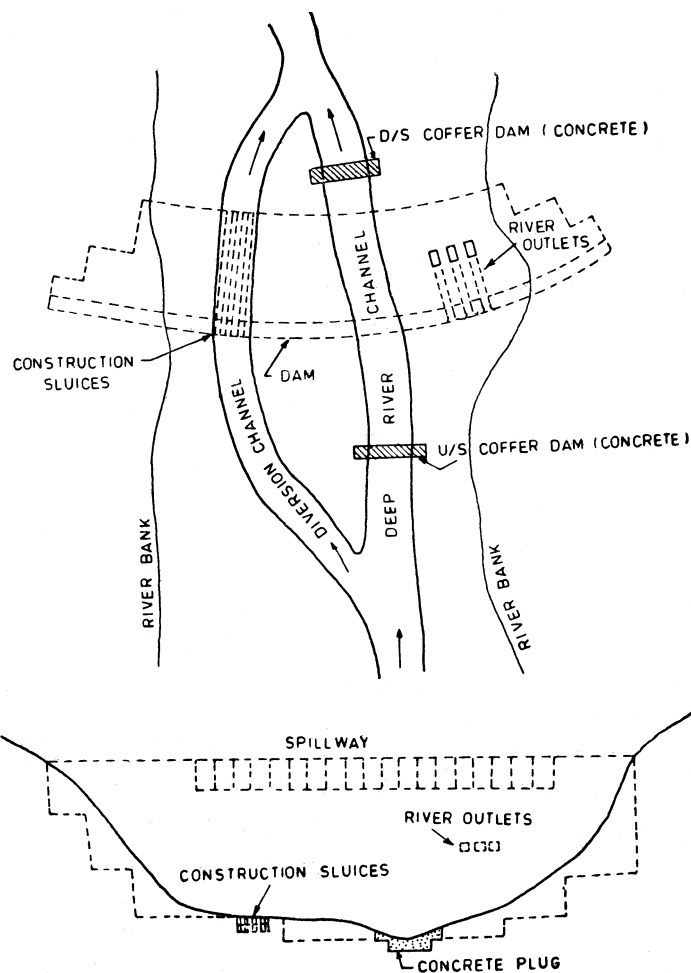


FIG. 1 DIVERSION CHANNEL FOR CONCRETE/MASONRY DAM IN A WIDE RIVER

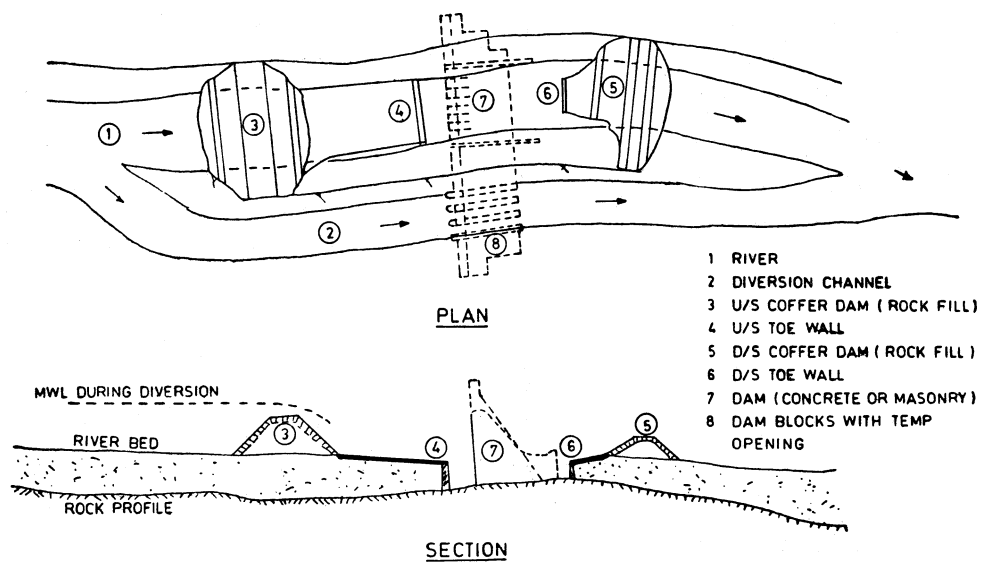


FIG. 2 DIVERSION CHANNEL FOR CONCRETE/MASONRY DAM IN A NARROW RIVER

water level, either during diversion of non-monsoon flows or passage of monsoon floods is lower than top level of the dam during construction. Magnitude of the diversion flood should be worked out on the basis of IS 14815. Because of the large volume of flood to be negotiated and the fact that earth dams are generally located in the main river gorge, diversion channels have to be excavated on one of the river banks in the case of narrow valleys. The layout and principal dimensions, specially the cross-section of the diversion channel is governed by several considerations such as topography, volume of flood to be handled, water levels during passage of monsoon and non-monsoon floods in consonance with raising of the dam and requirement of excavated material from diversion channel for use in constructing earth dam, etc. The coffer dams in such a case which form integral part of the earth or rockfill dam in the finally completed stage, are also not allowed to be overtopped (though a few examples exist when earth or rockfill dams have been allowed to be overtopped during diversion with special protection on their slopes with concrete blocks or gabions, etc). Because of the considerable expenditure and time involved in the construction of diversion channel for earth dams, these channels may be explored to be utilized for other purpose also such as spillway tail channel or power house tail channel. Although, initially such channels may be without protective lining on the sides, they are protected at a subsequent stage when utilized for spillway or power house tail race channel.

Figure 3 shows typical example of diversion channels for earth/rock fill dam project, in a narrow river channel.

4.1.2.2 In a wide river channel, provided the height of the earth dam is small enough, diversion could be managed by a temporary channel involving a gap through earthfill dam while the remainder of the embankment is being constructed (*see* Fig. 4). Before the stream is diverted, the foundation required for the dam should be completed in the area where the temporary opening will be left through embankment. This preparation would include excavation and refilling of a cut-off trench, if one is to be constructed. The stream is then channelized through this area after which the foundation work in the remainder of the stream bed is completed. The portion of the embankment on either side of the diversion opening may then be completed. The side slopes of the opening should be adequate and duly protected by suitable means such as gabions, retaining walls etc. The protection measures should be dismantled before the plugging of the diversion channel. The slope also provides a good bonding surface between the previously constructed embankment and the material to be placed. The bottom level of the temporary channel through embankment should be the same as the original stream bed, so that erosion in the channel will be minimized. The width of the opening will depend on the magnitude of the diversion flood and consideration of the equipment

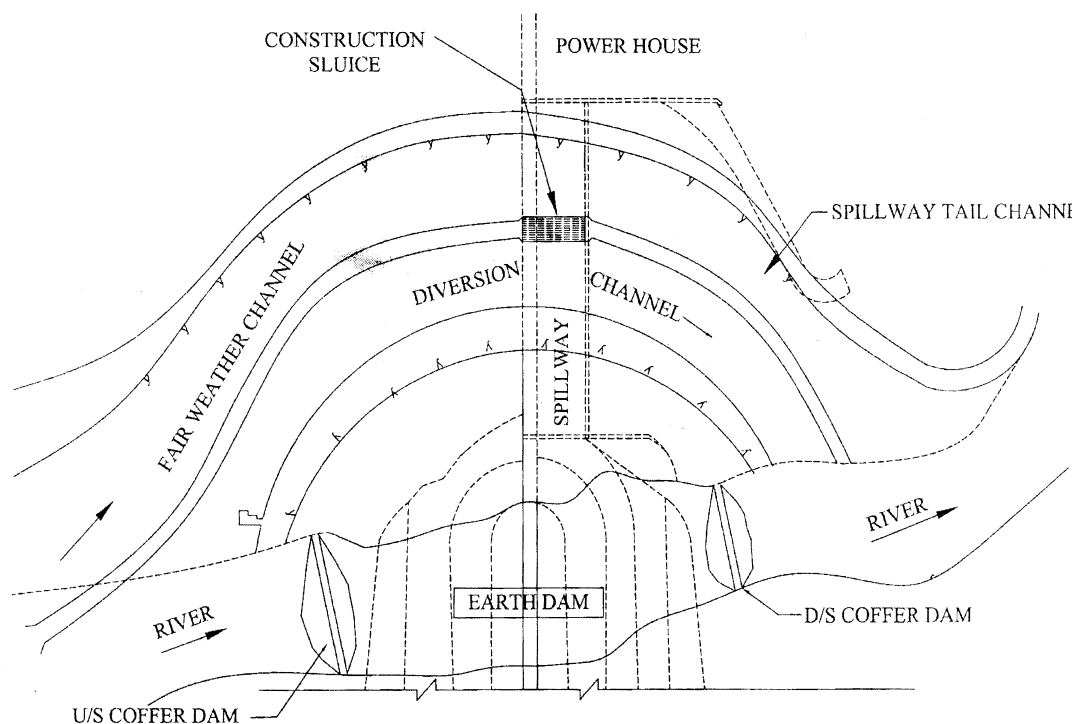


FIG. 3 DIVERSION CHANNELS FOR EARTH/ROCKFILL DAM IN NARROW RIVER CHANNEL

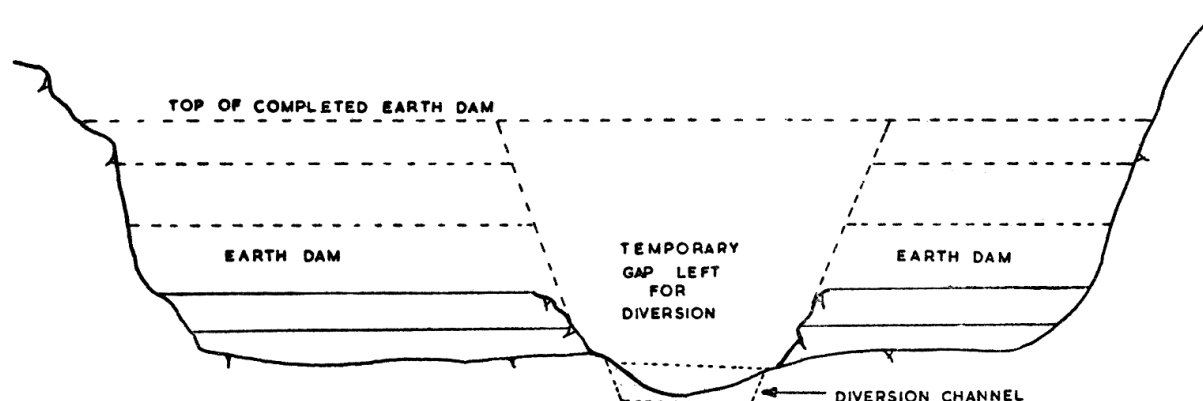


FIG. 4 DIVERSION THROUGH A GAP IN THE EARTH DAM IN A WIDE RIVER CHANNEL

capabilities for filling the gap which would be available. Care should be exercised during filling of the gap so that the quality of the work is not sacrificed due to exigencies of the situation. This is of great importance because frequently the diversion gap is in the area where the dam would be of maximum height. Special attention should also be given to bonding of the newly placed material with earth fill previously placed.

4.2 Design Consideration

The following points should be considered in the design of open channel for diversion:

- a) Although the alignment of the diversion channel is governed by topography, circular alignment is by far the most efficient alignment. The radius of the circle should be 3 to 5 times the bed width of the channel to obtain equitable flow across the channel. However, radius as small as twice the bed width may also be adopted because of the restraints due to other considerations;
- b) Channels are designed on the basis of Manning's formula, after adopting suitable value of rugosity coefficient depending on site conditions. The velocity in the unlined and lined channels should not exceed 5 m/s and 10 m/s respectively. While designing care should be taken for the following:
 - 1) Protection by rip rap, if required in case of unlined channel;
 - 2) Protection of the lined channel so that the lining doesn't get damaged for the design velocity; and
 - 3) Analysis should be made to ensure stability of channel and to ensure there is no formation of hydraulic jump.
- c) It is also advantageous to provide a fair weather flow channel within the diversion
- d) When the dam is raised and operation of construction sluices becomes difficult, diversion of non-monsoon flows could be effected through river outlets provided in the body of the spillway or dam. Often these outlets are used for irrigation/power outlets after completion of the dam;
- e) Although diversion of flow through open channel is for temporary use, the requirement of diversion continues for some years. In such a condition, it becomes necessary to ensure equitable distribution of discharge across the width of the diversion channel. For this purpose groynes or spurs could be effectively used to ensure satisfactory flow conditions in the diversion channel (*see Fig. 3*);
- f) For the diversion channel excavated in overburden, it is also necessary to ensure that the banks are not eroded due to flood flows. While provision of a spur could help ensuring concentration of discharge in the central portion of the channel with minimum velocities along the banks, it nevertheless requires protection to avoid erosion of the banks. If the diversion channel is to be utilized as spillway channel or power house tail race channel, the protection measures are designed

such that those could be useful during permanent stage also. In other cases, pitching with stones, rip rap or gabions is normally adopted.

5 OPEN CUT OR CONDUIT

5.1 The river floods may be so large that provision of diversion passages even for average floods may be alternative highly expensive. The only is to have them passed over or through the dam, although this does apply mostly to concrete dams. Smaller floods occurring during non-monsoon period are handled by temporary low level outlets works, permanent outlets works or other diversion arrangements while the monsoon floods are passed by over topping certain dam blocks purposely left at low level than others.

5.2 The capacity of diversion arrangement should be worked out on the basis of IS 14815. The conduit for diversion arrangement has to be designed normally as an outlet sluice in the body of the dam, that is, the reinforcement details should be worked out according to standard design criteria. The diversion conduit would normally be a rectangular conduit with height/ width ratio of 1.5/1.0 to 2.0/1.0. It would be desirable to flare the downstream end of the conduit to reduce the discharge intensity. Structural design of conduit should be done according to IS 12966 (Part 2).

If the conduit/sluice is used as a permanent structure, permanent gates and hoisting arrangement should be provided. In case the conduit/sluice is to be closed after diversion, there is no necessity of providing a gate in the body of the sluice but a bulk-head gate on the upstream with proper guidance for closing purposes may be provided. The permissible velocity in the conduit may be limited to 20 m/s, subject to the

condition that it is used for diversion purpose only. It is necessary to see that diversion channels and diversion tunnels are steel lined from intake to end of transition to avoid damage to the invert and sides due to rolling boulders, if carried in rivers.

The pressure fluctuations under transient flow conditions should be -examined closely. It should also be ensured that change from free surface to pressure flow take place smoothly.

The conduit should preferably be in the non-overflow block of the dam close to the spillway portion. Proper care should be taken for the dissipation of the energy at the outlet of the diversion conduit.

6 CLOSURE

When diversion channel and open or conduit in the body of the dam is no longer required for construction purpose, they should be closed as recommended in IS 13912.

7 MODEL STUDIES

Hydraulic model studies for evolving suitable arrangement of the diversion through open channel are almost indispensable. The model studies help deciding the most efficient alignment of the diversion channel, heights of the upstream and downstream coffer dams, protection measures for the coffer dams if they are to be overtopped, flow conditions in the diversion channel and protection measures for the diversion channel depending on its utility during diversion as well as during permanent stage. The discharging capacity of partly constructed spillway blocks could only be assessed through model studies as no accurate theoretical approach is still available for such a complex three dimensional flow situation.

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